EGU General Assembly 2020

A High-Resolution, Model-Based Lightning Risk Map for Turkey

Mustafa Yağız Yılmaz[1], Ozan Mert Göktürk[2], and **Güven Fidan**[3]

[1]Alkazar Technology, İstanbul, Turkey (yagiz@alkazar.com.tr)
[2]Bjerknes Centre for Climate Research, University of Bergen, Bergen, Norway (ozanmert@gmail.com)
[3]Alkazar Technology, İstanbul, Turkey (guven@alkazar.com.tr)

alkazar

Outline

Introduction

- It is crucial to know effects of lightning at a region to ensure public safety and to reduce financial damage.
- **Where** and **How frequent** are the key questions.
- Risk maps can provide some answers.
- It is important to make accurate and fast calculations. But it is not easy to obtain both at the same time.
- McCaul’s lightning scheme (McCaul, 2009) in WRF model is used to estimate lightning counts and to create a lightning risk map for Turkey.

Methodology
Observational Data for Calibration Region

- Lightning Observational data from *Blitzortung.org* is used for calibration.
- Because there are not enough data in Turkey to investigate accuracy of output, calibration calculations are made for Graz, Austria.
- 20 × 20 grid points are used.
- Calibration time is 1 year.
- Yearly total lightning variable is used.

Methodology
Numerical Simulation for Calibration Region

- WRF model version 4.0 is used.
- Calibration time: 01.01.2018 - 31.12.2018
- 3 km spatial resolution
- Physical parametrizations
    - **Microphysical:** WSM 6-class graupel scheme
    - **Cumulus:** No Cumulus scheme
    - **Boundary-Layer:** YSU scheme
    - **Land-Surface:** Noah Land-Surface Model
    - **Surface-Layer:** Monin-Obukhov Similarity scheme
    - **Longwave & Shortwave Radiation:** RRTMG scheme
- Yearly total variables are used.

Methodology

Calibration 1/3

In the study of McCaul et al. (McCaul, 2009), there are 2 different calculations are added together.

1. Upward flux of graupel in the mixed-phase region at -15 °C is calculated in *equation 1* (Peterson, 2005). It is better at temporal sensitivity.

$$F_1 = k_1 (w q_g)_m \quad (1)$$

$\boldsymbol{k_1}$: calibration coefficient based on observational data
$\boldsymbol{w}$: vertical velocity at -15 °C mixed-phase region
$\boldsymbol{q_g}$: graupel mixing ratio at -15 °C mixed-phase region

Methodology
Calibration 2/3

2. Vertical integral of graupel, snow and cloud ice is calculated in *Equation 2* (Cecil, 2005). It is better at areal representation.

$$F_2 = k_2 \int \rho\left(q_g + q_s + q_i\right) dz \qquad (2)$$

$\boldsymbol{k_2}$: calibrated based on observational data
$\boldsymbol{\rho}$: local air density
$\boldsymbol{q_g}$: mixing ratio of graupel
$\boldsymbol{q_s}$: mixing ratio of snow
$\boldsymbol{q_i}$: mixing ratio of ice

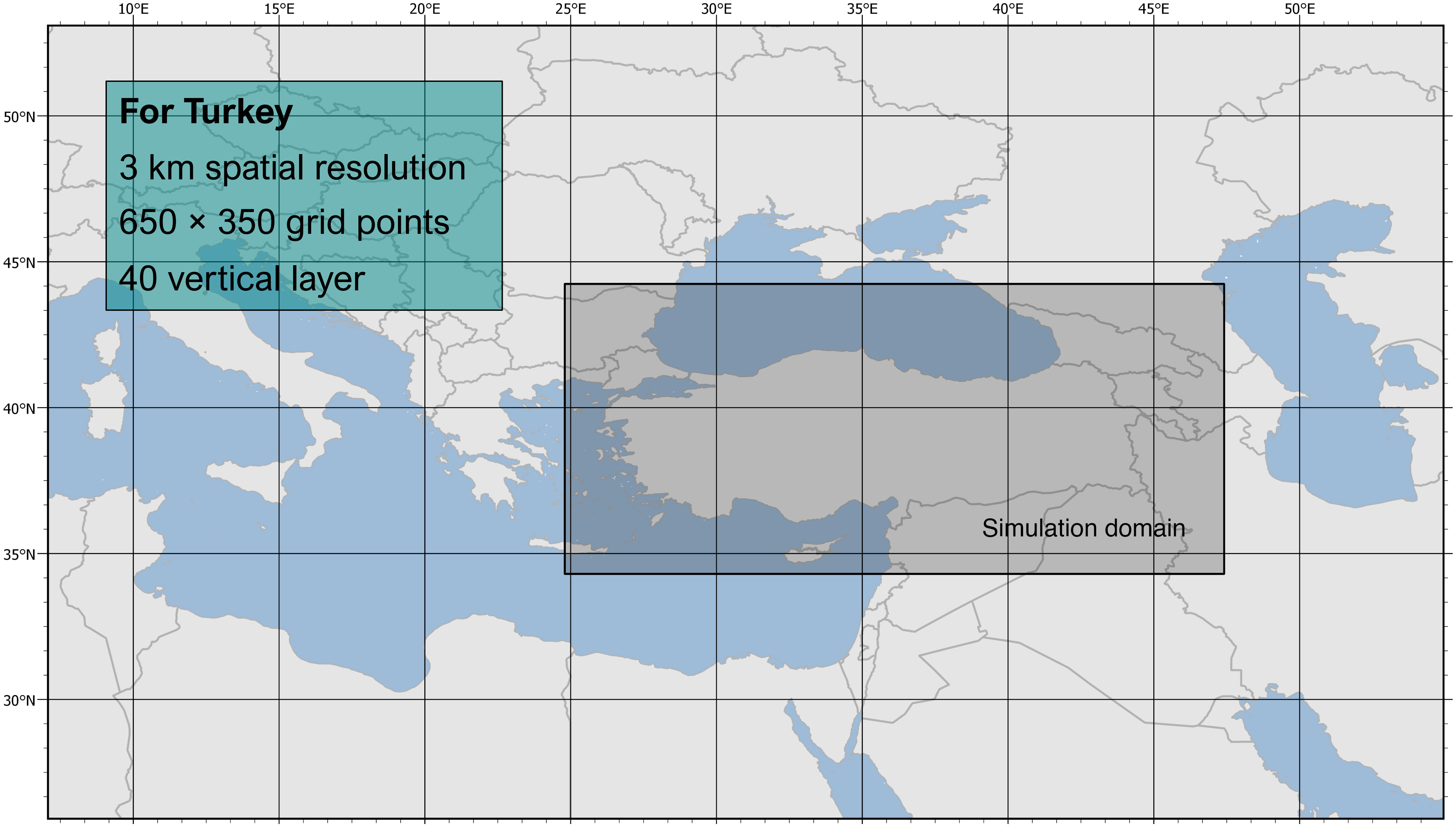
Methodology
Calibration 3/3

- F_1 and F_2 are calibrated based on observational data.
- *Equation 3*, calibrated lightning data, is calculated.

$$F_3 = 0.95F_1 + 0.05F_2 \quad (3)$$

Methodology
Numerical Simulation for Turkey

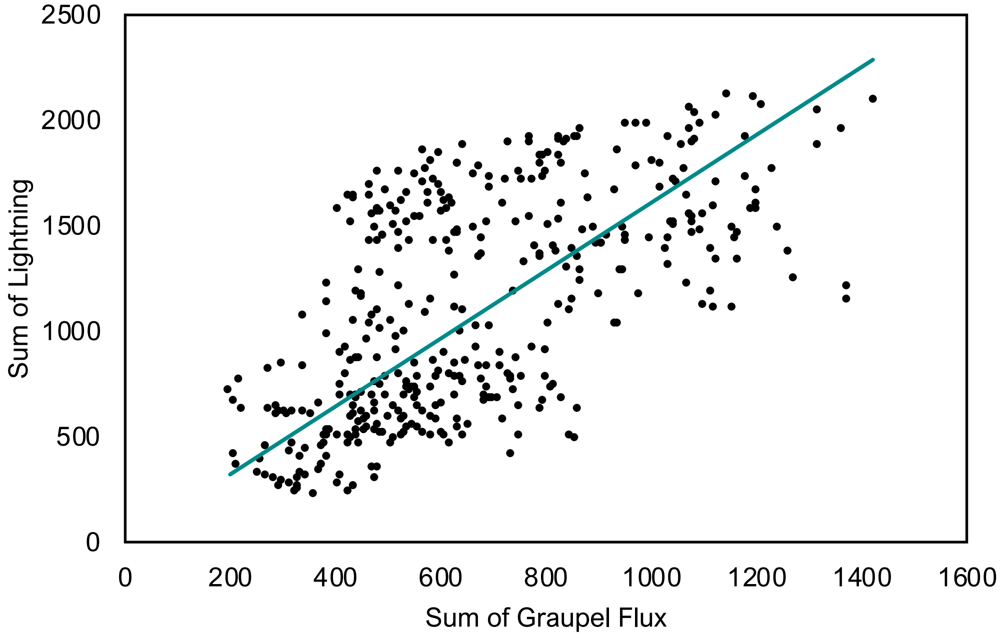
- WRF model version 4.0 is used.
- Validation time: 01.01.2014 - 31.12.2018
- Physical parametrizations
  - **Microphysical:** WSM 6-class graupel scheme
  - **Cumulus:** No Cumulus scheme
  - **Boundary-Layer:** YSU scheme
  - **Land-Surface:** Noah Land-Surface Model
  - **Surface-Layer:** Monin-Obukhov Similarity scheme
  - **Longwave & Shortwave Radiation:** RRTMG scheme
- Yearly total variables are used.


10°E
15°E
20°E
25°E
30°E
35°E
40°E
45°E
50°E
50°N
45°N
40°N
35°N
30°N
For Turkey
3 km spatial resolution
650 × 350 grid points
40 vertical layer
Simulation domain

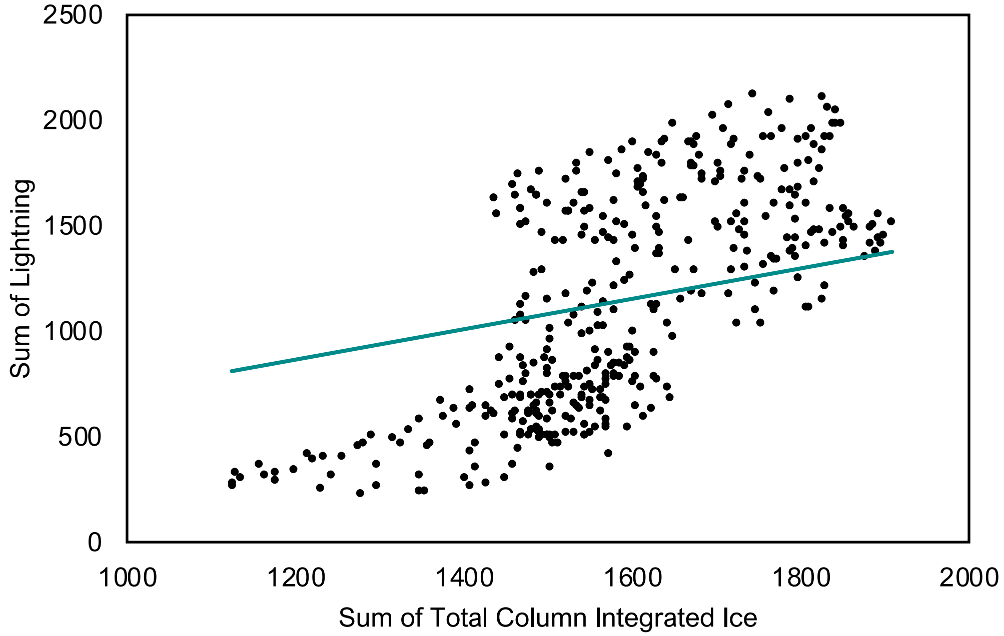
alkazar

Results
Calibration Region 1/2

Calibration coefficients are obtained from slope of the equations calculated by using linear regression method.



$$y = 1.6091x$$
$$F_1 = 1.6091(wq_g)_m$$



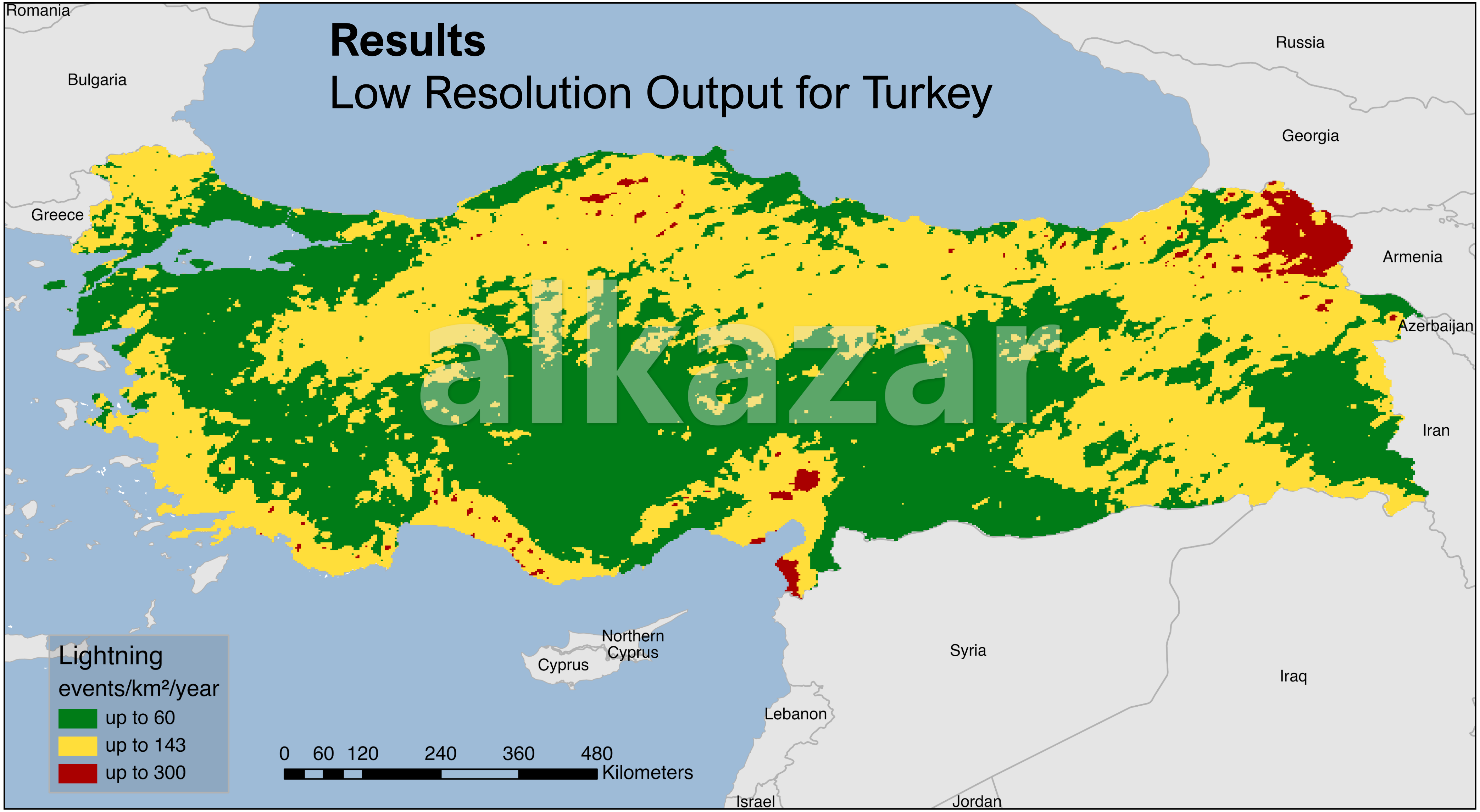
$$y = 0.721x$$
$$F_2 = 0.721 \int \rho(q_g + q_s + q_i)dz$$

Results
Calibration Region 2/2

Statistical results for 400 grid points on the calibration region

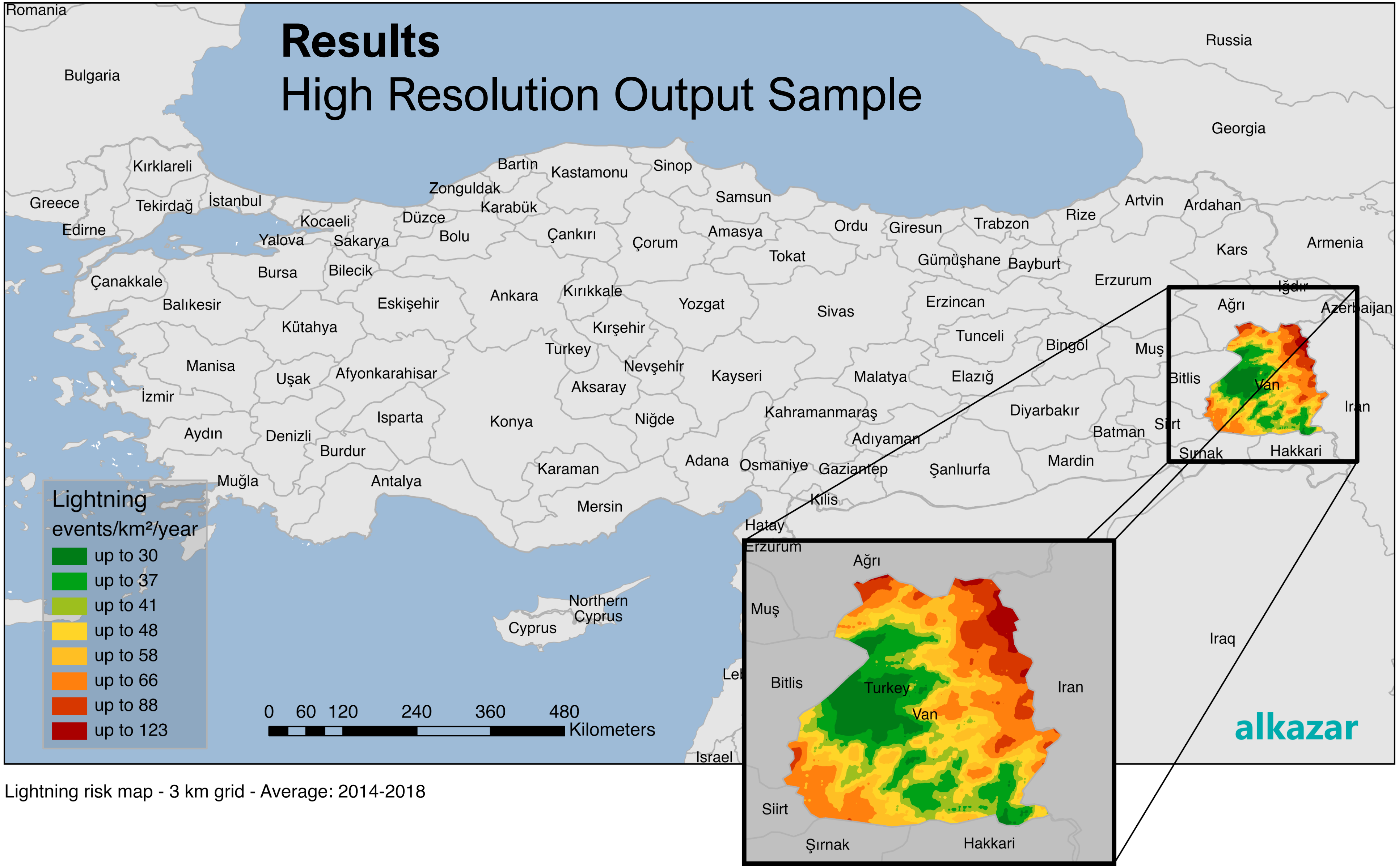
Method	Equation	Value
Pearson's correlation coefficient	$r_{xy} = \frac{\sum_{i=1}^{n} (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n} (X_i - \bar{X})^2} \sqrt{\sum_{i=1}^{n} (Y_i - \bar{Y})^2}}$	0.62
RMSE (root mean square error)	$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (X_i - Y_i)^2}{n}}$	416
SMAPE (symmetric mean absolute percentage error)	$SMAPE = \frac{\sum_{i=1}^{n} \lvert X_i - Y_i \rvert}{\sum_{i=1}^{n} (X_i + Y_i)}$	0.33
MAE (mean absolute error)	$MAE = \frac{1}{n} \sum_{i=1}^{n} \lvert X_i - Y_i \rvert$	343

Results
Low Resolution Output for Turkey



Lightning risk map - 3 km grid - Average: 2014-2018

Results
High Resolution Output Sample



Lightning risk map - 3 km grid - Average: 2014-2018

Conclusion and Outlook

- Locations where either high value or low value expected, are became coherent with observational data after calibration.

- Our study is involved whole Turkey, but we gave only one detailed province for being sample.

- If you are interesting with our work;

  https://alkazar.com.tr/

  info@alkazar.com.tr

Acknowledgements

- Blitzortung.org
- Amazon Web Services
- Esri

References

- McCaul, E.W., S.J. Goodman, K.M. LaCasse, and D.J. Cecil, 2009: Forecasting Lightning Threat Using Cloud-Resolving Model Simulations. Wea. Forecasting, 24, 709-729, https://doi.org/10.1175/2008WAF2222152.
- Petersen, W. A., H. J. Christian, and S. A. Rutledge, 2005: TRMM observations of the global relationship between ice water content and lightning. Geophys. Res. Lett., 32, L14819
- Cecil, D. J., S. J. Goodman, D. J. Boccippio, E. J. Zipser, and S. W. Nesbitt, 2005: Three years of TRMM precipitation features. Part I: Radar, radiometric, and lightning characteristics. Mon. Wea. Rev., 133, 543-566.
- W.J. Koshak and R.J. Solakiewicz, 2001: TOA Lightning Location Retrieval on Spherical and Oblate Spheroidal Earth Geometries. Journal of Atmospheric and Oceanic Technology,18(2),187-199.